Wavelength-dependent Smithsonian Astrophysical Observatory Air Mass Factor Tables for UV/Vis retrirevals

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Motivation

Air Mass Factors (AMFs) link the total vertical column with the fitted slant column according to the equation

$$AMFs = SlantColumn / VerticalColumn$$

Traditionally the AMFs have been calculated for specific wavelengths of the fitting window but unfortunately this approach to the problem is unable to account for their wavelength dependence. To address this problem in the retrieval of total vertical columns of weakly absorbing species the cross sections can be weighted by the AMFs before the fitting of the spectra. Using this technique total vertical columns are retrieved directly during the fitting process. The existing look up tables don't have the necessary spectral coverage for these retrievals. A new set of tables have been built.

To calculate the AMFs we follow Palmer et al. 2001, decoupling the scattering weights and the vertical shape factor.

$$AMF = AMF_G \int_0^\infty w(z) S_z(z) dz$$

The new tables only contain information about the scattering weights, calculated using the radiative transfer code VLIDORT (Spurr, 2006) stored as radiances and Jacobians. It will be during the retrieval process where actual AMFs will be calculated using climatologies built with GEOS-Chem in the case of tropospheric species or other studies in the case of species with significant stratospheric concentrations.

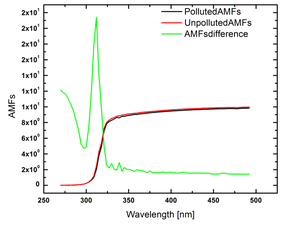
The scattering weights have been calculated using ozone normalized weighting functions, since the greatest contribution to the AMFs other than the geometrical factor is due to the absorption by O_3.

Radiance and Jacobians calculations

Given that the scattering weights can be calculated as

$$SW = Jacobian / I \cdot \sum x_s$$

where I is the radiance and x_s are the absorption cross sections the tables contain the radiance, the normalized Jacobians, the temperature and O_3 profiles and the O_3 cross sections. The spectral range of the calculations covers from 260 nm to 500 nm with a resolution of 0.01 nm. 72 altitude levels using GEOS-5 Native Vertical Grid and 26 temperature and O_3 profiles from TOMS v7 climatology have been used in the 260 nm – 375 nm spectral range while for the 375 – 500 nm region only one profile has been (m325) used. Water vapor from the standard US atmosphere, BrO and NO_2 profiles are also included in the calculations. The calculations have been performed for a set of solar zenith angles (SZA), viewing angles (VZA), relative azimuth angles (RAA), albedos (ALB) and cloud top pressure (CTP) levels. The presence of clouds has been modeled in VLIDORT assuming a Lambertian surface at the required pressure with an effective albedo of 0.8.



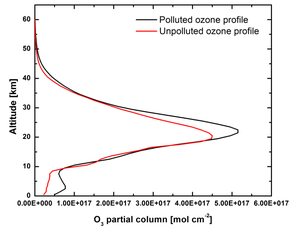


Table parameterization

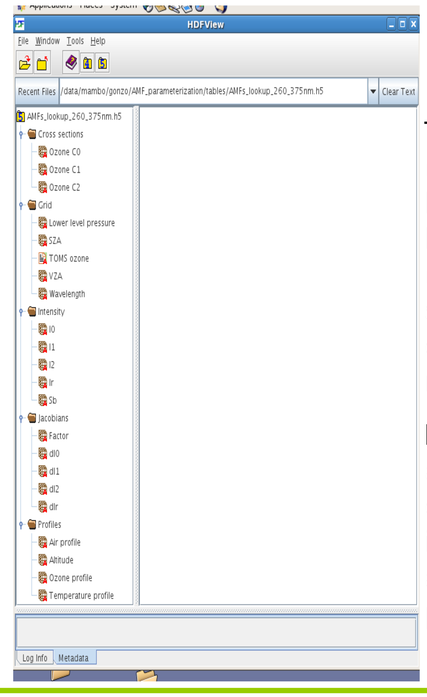
To reduce the size of the tables and to avoid the need for albedo and RAA interpolation in their use the tables have been parameterized using the TOMRAD equation (Bhartia, 2001):

$$I = I_0(\theta_0,\theta) + I_1(\theta_0,\theta)\cos(\phi) + I_2(\theta_0,\theta)\cos(2\phi) + \frac{RI_r(\theta_0,\theta)}{(1-RS_b)}$$

where I_0, I_1,I_2 and I_r depend on the viewing geometry (SZA and VZA) and S_b is only dependent of the surface Φ being the RAA. The Jacobians have been parameterized to:

$$\frac{dI}{dO_3} = \frac{dI_0(\theta_0,\theta)}{dO_3} + \frac{dI_1(\theta_0,\theta)}{dO_3}\cos\phi + \frac{dI_2(\theta_0,\theta)}{dO_3}\cos 2\phi + \frac{R}{1-RS_b}\frac{dI_r(\theta_0,\theta)}{dO_3}$$

HDF-5 format



To save space and optimize the input/output the tables have been stored using hdf5. The screenshot on the left shows the file structure for the table covering the 260 to 375 nm region.

In addition to the radiance and Jacobian parameters, other useful information including cross sections and ozone profiles are present in the files.

SZA	0º	15º	30º	45º	60º	70º	77º	81º	84º	86º	88º	89º
VZA	0º	15º	30º	45º	60º	70º	75º	80º				
RAA	0º	30º	60º	90º	120º	150º	180º					
ALB	0.00	0.01	0.03	0.06	0.09	0.12	0.15	0.18	0.33	0.66	1.00	
CTP	0.24	0.37	0.52	0.63	0.83	1.00						

Selected references:

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P. K. Barthia and W. C. Wellemeyer: "TOMS-V8 total O_3 algorithm in: OMI Algorothm Theoretical Basis Document, Volume II: OMI ozone products", edited by P. K. Bhartia and M.D. Greenbelt,51-73, 2001

Acknowledgements:

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